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THE WISCONSIN COASTAL MANAGEMENT PROGRAM, part of Wisconsin Department of Administration, and overseen by the WISCONSIN COASTAL MANAGEMENT COUNCIL, was established in 1978 to preserve, protect and manage the resources of the Lake Michigan and Lake Superior coastline for this and future generations.

The Project Team

This project required coordination and completion of several steps including map documentation, photo preparation, photo interpretation, digital area/linear measurement and data sheet preparation. The following students worked as a team to help complete this project.

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Assessing Coastal Development Along Wisconsin's Great Lakes Shoreline: 1978 - 1992

Coastal Management Program Contract No. 840005-501.15

INTRODUCTION

The Wisconsin Coastal Management Program mission includes developing an understanding of change along the state's Great Lakes shoreline. Such change, of course, can be natural or human-based. This study was undertaken to document natural and human-based development within the coastal zone of the state's Lake Michigan and Lake Superior shorelines. The Wisconsin legislature has defined coastal zone as land within 1,000' (304.8 meters) of the shoreline (Ordinary High Water Mark - OHWM).

Future coastal zone planning and risk assessment requirements defined the types of data to be collected. Assessment of risk to structures built in the coastal zone requires a temporal analysis of structural development and shoreline modification(s). Planning of the coastal zone requires, as well, determination of the natural resource base. This study utilized U.S. Army Corps of Engineers historic color aerial photographs taken in 1978 and 1992.

This report documents both the original and amended contract to assess natural and developmental change within the coastal zone of Wisconsin's Great Lakes shorelines. Although the original contracted work was interrupted to include elements of the amended contract, no attempt will be made in this report to keep separate original vs. amended objectives, procedures or results. Goals of the amended contract include and expand those of the original.

PROJECT GOALS

Planning and assessment of hazards within the coastal zone defined the goals of this study. Within the Lake Michigan and Superior coastal zones, project goals included:

- Development of land use databases for 1978 and 1992
- Development of 1978 and 1992 databases of human modification of the shorelines
- Develop a database of built structures for 1992 Additional goals included:
 - Assess land use change within the coastal zone from 1978 to 1992
 - Assess human modification of the shoreline from 1978 to 1992

STUDY AREA

The project study area comprises the Wisconsin portion of the Lake Michigan and Lake Superior coastal zone (Figure 1). In 1982, the Wisconsin state legislature defined coastal zone as being that land within 1,000 feet (304.8 meters) of lake shoreline. Accordingly, the study area represents a 1,000' wide



Figure 1. Coastal Counties of Lake Michigan and Lake Superior

zone, the landward boundary of which is parallel to the coastline.

PROJECT METHODS

Aerial Photography

Using aerial photos to assess coastal development requires clear statement of goals, appropriate definition of coastal zone, meaningful classification scheme, appropriate historical and current aerial photos, appropriate interpretation procedure and method of documentation, and trained personnel.

Application of aerial photography to assess urban and natural resource features is documented well (Smith, 1968; Avery and Berlin, 1985; Lo and Noble, 1990; Ciciarelli, 1991; Boge et al., 1992; Hinckley and Walker, 1993). Specific applications to urban/human activities cover a wide range including urban nonpoint pollution assessment (Kim and Ventura, 1993), gully erosion analysis (Welch et al., 1985), historical analysis of urban development into coastal wetlands (Niedzwiedz and Batie, 1984), identifying structural additions to urban residential property (Niedzwiedz, 1990), and studying agricultural land use (Marsh et al., 1990).

Aerial photos have been used to map archeological sites, urban features, and to document changes to the landscape (Smith, 1968). MacConnell (1975) reports the use of black and white aerial photography (scale 1:20000) to map 20 years of land use change within the state of Massachusetts, including the coastal zone. As part of a larger Great Lakes study, the International Joint Commission (1993) used 1:24000 scale photos to map land use features along the Berrien County, Michigan segment of the Lake Michigan shoreline. Results of the photo analysis were used to assess residential riparian erosion/recession rates caused by fluctuating water levels.

Wisconsin's coastal zone includes diverse land use, from forests and wetlands, to land devoted to agricultural or urban uses. The uses of aerial photos long have been applied to study such land uses. Befort and Viliman (1985) studied aerial photos to classify forest habitat. McCarthy et al. (1982) evaluated spruce-fir forests to aid management. Wetlands analysis is possible with aerial photos of appropriate format, scale and seasonal timing. Scarpace et al. (1981) used digitized aerial photos to map wetlands, while Ferguson et al. (1993) and Barrett and Niering (1993) have monitored sawgrass habitat and marsh vegetation change using aerial photos.

Extensive use of aerial photography has been directed at coastal resources. Scherz and Van Domelsen (1973) used aerial photos to help assess water quality in Lake Superior near Duluth, Minnesota. Numerous studies have been made with aerial photos to aid management of coastal resources (Benton et al., 1978; Hill et al., 1985; Norton et al., 1985; Welch et al., 1992), to address change in coastal wetlands (Lyon and Greene, 1992), and to

examine urban development into coastal wetlands (Niedzwiedz and Batie, 1984).

Project Aerial Photos

In 1978, the U.S. Army Corps of Engineers (USACE) obtained panchromatic color aerial photos of the Wisconsin portion of the Lake Michigan coastline. In 1992, USACE obtained color aerial photo coverage of the Wisconsin portion of both Lake Superior and Lake Michigan coastlines. Both the 1978 and 1992 photos were flown at a scale of 1:6000 (1" = 500') and enlargements made at 1:2400 (1" = 200'). The 1978 photos were taken April 16th. The 1992 photos were flown May 13th.

Unlike most historical aerial photos covering the same area and flown at the same scale, the USACE photos of 1978 and 1992 were not flown with coincident photo centers or coverage. No individual flight lines were documented for the 1978 photos. Beginning at the Michigan border, the 1978 photos were taken incrementally to the Illinois border. Photos are documented with the photo date and photo number on the northern edge of each photo.

Flight lines were documented for the 1992 photos. Flight line #1 begins just south of the Wisconsin-Illinois border. The northern edge of each 1992 photo displays the photo date, flight line and photo number.

Both the 1978 and 1992 photo contact prints (1:6000) were flown to produce stereo coverage of the coastline. Adjacent photos overlap (endlap) about 60% with each other. The enlarged photos (1:2400) available for this study represent every other photo contact print, therefore, only photographic, not stereo coverage, is provided by the enlarged photos. Approximately 1,800 photos (1:2400) cover Wisconsin's Lake Michigan shoreline, 900 for each flight year. About 1,200 photos covering the shoreline from Marinette to Sheboygan are on file at the Green Bay office of USACE. The Waukesha office of USACE has on file about 600 photos covering the shoreline from Sheboygan to the Illinois border.

Photo Preparation

Photos used in this study are owned by USACE. As a result, all photo documentation and interpretive work was applied to acetate affixed to each photo. Preparing photos for interpretation included the following:

- 1. Affix label and document photo number/flight line, photo date and Public Land Survey System (PLSS) information.
- 2. Mark photo fiducials (orange ink). Fiducials allow the registration of acetate overlays to the photos, if required.
- 3. Mark control points (orange ink). Typically these points are road intersections and, or buildings, stable objects

that could be referenced against controlled maps for future mapping applications.

- 4. Locate and mark interpretation boundary lines (black ink). These lines are used to denote a common boundary between adjacent photos. Land use interpretive lines end at these boundary lines, which eliminates redundant interpretive work.
- 5. Locate, mark and label PLSS section lines (red ink).
- 6. Locate, mark and label civil boundary lines (green ink).
- 7. Locate and mark 1,000' coastal zone boundary line (blue ink). A divider was used to scribe a line 1000' away and parallel to the line defined by land meeting water. In cases where large streams entered Lake Michigan, a straight dashed line was drawn to represent a continuation of the shoreline.
- 8. Locate and mark top of bluff, and bottom of bluff if slumpage is evident (black ink). In practice, these lines were not drawn until the shoreline portion of the classification scheme was applied to the photos. Refer to the section Photointerpretive Process (page 11) for additional discussion.

Aerial Photo Interpretation (API)

The landscape within the coastal zone can represent a complex mix of natural to urban uses. The land use classification scheme developed for this study addresses the complexity of Wisconsin's coastal zone. The scheme is a modification of the scheme developed by International Joint Commission (1993) and includes the general use categories of residential, commercial, industrial, transportation, extractive, agricultural, natural, open land and other uses. Land uses have been measured by area (acres, hectares). Structures per land use have been located and marked for spatial reference. Structures are tallied by type for 1992.

Modification of the shoreline also has resulted. Sea walls, revetments, groins and permanent docks have been constructed. Sea walls and revetments are linear types. Their interpretation and measurement are presented in feet (meters). Groins and docks were counted.

CLASSIFICATION SCHEME

Residential Land

All residential areas include infrastructure to service the area. Boundary placement is made to separate residential areas by type. No attempt is made to distinguish roads/streets from the residential areas they serve. This convention is true for other classification types as well.

- Multi-Family: Medium to High Rise. Large residential structure of five (5) or more stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 112 Multi-Family: Low Rise. Large residential structures up to four (4) stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 113 Single Family, Duplex. Structures large and small used for residential use. The type includes lawn, landscaped areas, garage and driveways. Duplex structures are identified by twin driveways or a very wide driveway leading to an architecturally balanced structure.
- 115 Mobile Home Park. Residential area developed exclusively for mobile units.

Commercial and Industrial Land

Commercial land includes three (3) types: central business district; shopping center/mall; and, neighborhood business district. Each type includes all building structures, access roads/streets, parking facilities and other features commonly associated with each type.

- 121 Central Business District (CBD). Commercial land predominantly used for distribution or merchandizing of goods and services. Stores, hotels, office buildings, parking facilities and smaller warehouses constitute the components of this type. The CBD spatially is tight, vegetation is rare.
- Shopping Center/Mall. These commercial areas have developed away from the CBD. The type includes both "strip" type development and malls. Structures can range from large, flat roofed and rectangular (centers) to large, geometrically shaped. Both types include large parking areas adjacent to or completely surrounding the commercial structures.
- Neighborhood Business District (NBD). This type denotes small commercial areas within, or adjacent to residential areas. The type may be found in established or newer subdivision areas. NBD structures can range from conventional architecture to unusual geometric shapes. Small parking areas are associated with NBD commercial areas.

126 Institutional Land. The type reflects areas devoted to public or quasi-public uses. Examples include schools, churches, hospitals, prisons, etc., and their associated "grounds," green space, landscaping and parking facilities. When located within the CBD, public buildings without "grounds" often cannot be identified on aerial photos and would be classified as commercial (121).

Industrial Land

138 Industrial Park. The type includes both heavy and light industrial use areas.

Heavy industrial land contains facilities for the manufacture, storage and assembly of raw or partially processed products such as machinery, metals, chemicals, petroleum, or electrical power. Such industries often have large smokestacks and large storage areas. Warehouses and transportation facilities for bulk products and an open and interrupted street pattern characterize this type.

Light industrial land contains facilities for the manufacture or assembly of smaller, partially processed products such as electronics, appliances, and other secondary process products. Large smokestacks or raw material storage facilities are never present. Many modern light industries are well landscaped and are indistinguishable from commercial activity on aerial photographs.

Transportation Land

- 141 Air Transportation. Includes areas with airports and associated facilities, landing strips, hangers, parking areas and adjacent open areas.
- 142 Rail Transportation. This type includes railyards, terminal freight and storage facilities as well as stations for passengers. The type may include liquid storage facilities such as tank farms.
- 143 Water Transportation. This designation is applied to several water-based areas, including docks, warehouses and related land-based facilities for water transportation and commercial fishing. The type includes, as well, public marinas and their associated facilities: boat slips, buildings and parking areas.
- 143.1 Private Marina. Boat mooring areas adjacent to residential land are designated as private marinas. Often such areas include a protected slip(s), dredged waterway and, or a permanent docking structure built into the waterway.

- 143.2 Public Boat Landing. This type is applied to boat launching areas. Typically, facilities include only a ramp(s) from which boats may be launched and parking areas.
- 144 Divided Highway. This type includes transportation corridors with median strips between lanes. Typically, such roads are four or more lanes wide. Local streets are not included in this type.
- 145 Communications. Facilities and structures devoted to communications. These include radio/television towers, lighthouses and their grounds, buildings and parking areas.
- 146 Utilities. This type includes facilities for the production and distribution of energy. Such areas can include large buildings, towers, roads/parking facilities and, in the case of coal fired plants, large piles of raw coal.
- 147 Sewage Treatment Plant. Buildings, treatment lagoons, parking areas, access roads and grounds are included in this type.
- 148 Landfill. Landfill sites used to bury garbage define this type. Landfills cover an extensive area and are dominated by large excavated areas, mounds of exposed soil and access roads.

Extractive Land Use

- 171 Open Pit. The type represents open pit mining areas for extraction of sand, gravel, stone or rock. The type includes access roads and any structures.
- 172 Underground Mine. Mining of underground resources via shaft extraction. Surface features captured on aerial photos would be limited to small structures and access roads.
- 173 Well. Features associated with wells are limited. Identification of wells using only aerial photos is difficult.
- 179 Other Extractive Uses.

Agricultural and Natural Land

Abandoned Field (AF). These are agricultural units reverting to wild land. Woody vegetation and grass are abundant but tree crown cover is less than 30%. If tree crown cover were greater than 30%, the land would be classified as forest.

- 182 Agriculture Active (AG). Tilled or tillable crop land which is or recently has been intensively farmed. The boundaries on the ground usually are sharply defined and well maintained. The land supporting farm buildings is included as part of this type.
- 183 Forest (F). Areas of forest, deciduous, coniferous or mixed, having canopy closure of at least 30%. Areas with less than 30% canopy closure are classified as abandoned field.
- 184 Heath (H). Areas of heath plant community as well as grass, shrubs, and other low vegetation found on poor sandy soils.
- Open Water (W). Areas of open water found in lakes, rivers and large streams. Water depth is greater than three feet during the growing season. The boundary of coastal water is located by drawing a line at the river mouth to connect the edges of the coastline, or man-made features like roads, railroads or bridges crossing rivers or inlets are used to establish such a line.
- 186 Rock Ledge (RL). Rock outcrop areas at the coastline or within the coastal zone. Such outcrops are common in Door County.
- 187 Slump Zone (SL). Land located between upland bluff and beach. Slump zones begin at the bluff line and slope down to the beach.
- 188 Wetland (WT). This type covers the full spectrum of wetlands. These include seasonally flooded flats, shrub swamps, meadows, bogs, shallow and deep marshes, and forested wetlands. Each is described below.

<u>Seasonally flooded basins or flats</u> occur principally on stream floodplains. The most common plants are grasses and herbaceous species. The soil is waterlogged or covered with water during spring freshets, but well-drained during the growing season.

<u>Shrub swamps</u> often have waterlogged soil during the growing season, as much as six (6) inches of water may be present. Vegetation types include elder, buttonbush, dogwood and willow. Sedges usually are present in tussocks.

<u>Meadows</u> are vegetated with grasses, rushes and sedges. Soils are waterlogged through most of the growing season. Surface water is present only for a short period during the spring.

Bogs are unique wetland types that support a distinctive plant community, including most of the following: heath shrubs, cranberries, pitcher plants and sedges. Scattered black spruce, tamarack and red maple may be present. A mat of sphagnum moss is the most common feature of bogs.

Shallow marsh is wetter than meadow. The soil is completely waterlogged and often covered with up to six inches of water during the growing season. The predominant vegetation is emergent, including such plants as cattails, bulrushes, burreed, pickerelweed and arrowhead with some grasses and sedges present. The type is common to open water bodies.

<u>Deep marsh</u> has water depth ranging from six inches to three feet. Fairly large open water areas are bordered by, or interspersed with, emergent vegetation like that found in shallow marsh. Floating and submergent plants such as water lilies, duckweed, watershield and pondweeds also are present.

Forested Wetlands. This type represents areas of moist to saturated soil covered by forest canopy. The type is difficult to identify without stereo photography and, or with "leaves-on" photography.

Open and Other Land

- 191 Outdoor-Public Assembly
- 192 Urban Open Lots. Urban open is undeveloped land lying idle in the midst of urban areas or adjacent to them. This type includes land which has been cleared for urban development of an unknown use.
- 193 Outdoor Recreation. Outdoor recreation types are either mainly for participation, mainly for spectators, or are environmental in character. Each recreational type includes the recreational complex: access roads, parking facilities, buildings and other related facilities.

194 Cemeteries

Shoreline Modification

Development along the lakeshore often means modification at, or near, the shoreline. Land along the lakeshore is exposed to significant erosional forces. Recession of land mass is common. Agricultural and urban land uses destabilize shoreland, in effect accelerating erosion and land recession. To protect real estate and property, many property owners have constructed walls or revetments along their shoreline. Some owners also have built non-flow-through docks at the shoreline to provide mooring and protection for their boats. Groins, large rock structures perpendicular to the shoreline, have been built along Wisconsin's Lake Michigan shoreline.

195 Sea Walls (\underline{V} 195 \underline{V}). These structures are built parallel to the shoreline and typically are well defined, linear

features. Construction materials can include concrete, wood or interlocking sheet steel.

- 196 Revetments (<u>V 196 V</u>). Large rock or slab structures built parallel to the shoreline. Interpretively, revetments are less well defined, and appear wider than do sea walls.
- 197 Groins (* [red]). Groins are large rock structures built perpendicular to the shoreline into the water. Except for their distinct orientation and placement, groins appear similar to revetments.
- 198 Non-Flow-Through Dock (* [blue]). Such docks are permanent structures built into near-shore waters.

 Typically these docks are straight, their upper surface wide and well defined.

Structures - Industrial, Commercial and Residential

On the 1992 photos, buildings within the coastal zone are classified by type and location. Using a template of rectangles, for each building, a rectangle is selected that best represents the area of the building's "footprint." The selected rectangle then is positioned so that the leading edge of the building (relative to the shoreline) is located. Buildings for 1978 were counted by type. However, due to photo format differences, comparison of 1978 and 1992 structural counts may be inaccurate.

THE PHOTOINTERPRETIVE PROCESS

After photo preparation, each photo was interpreted using the classification scheme defined above. Area (land uses), linear (shoreline modification) and point (urban structures, groins, docks) types are represented in this study. Lines and, or symbols were used to define all types. Area types are represented by perimeter boundary lines and symbols to define and identify the areas. Line types representing modification to natural shoreline were defined using both lines and symbols. All area and line type symbols are recorded in black ink. Point types are defined by symbols and colored ink (see above).

Modifications to the shoreline, such as sea walls or revetments, are delineated by placing (painting) the 'V' symbol at the beginning and end of the modification. The type of modification is represented by placing the appropriate number between the 'V' symbols. For example, 195 positioned between two 'V' symbols means that a sea wall has been built along this section of shoreline. Shoreline classification was conducted before land use so that land use boundary lines placed along the shoreline would not 'hide' shoreline information.

Groins and non-flow-through docks were defined by point symbols (see above). In both cases, the symbol was placed at the point where the structure meets land. As discussed above, for

1992, buildings also were classified using point symbols. The delineation of buildings represents the last API procedure.

MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE

Area types (land use polygons) and line types (shoreline modification) measurements were made using the hardware/software facilities of the GIS Lab at the University of Wisconsin-Green Bay. Photo acetate overlays were affixed to large-format digitizers and each land use polygon digitized along the perimeter. Measurements recorded in square inches were converted to acres/hectares. Line measurements (in inches) of shoreline modifications were made using digitizers as well. Linear inch measurements were converted to linear feet/meters for each type of modification.

Point types (groins, structures) simply were tallied by count for each type. The area covered by each acetate was broken into civil jurisdiction and PLSS section designations.

Measurements (above) were separated by civil and PLSS designations as well, and documented permanently on each acetate overlay.

TALLY OF DATA

Measurements recorded on each photo acetate were transferred to data sheets. Three (3) levels of data sheets were used: PLSS Section Data; Civil Jurisdiction Summary Data; and County Summary Data (Appendix).

PLSS Section Data Sheet: One (1) PLSS Section Data sheet was used for each section located on a photo/acetate. Generally, 1-2 PLSS sections are located on a photo, however, up to four (4) sections per photo were recorded. Section level data sheets record photo documentation including photo year, photo number, county and community(ies) covered, and complete PLSS section location. Also recorded were number of residential, commercial, industrial and institutional structures (1992), area of land use by type, linear distance of sea walls and revetments, and the number of groins and non-flow-through docks.

Civil Jurisdiction Summary Data Sheet: This tally sheet summarizes the data for all PLSS section sheets found within each township, village or city. The sheet records photo year, county, name of civil jurisdiction, a complete listing of PLSS sections included in the summary, as well as all land use, shoreline and structure count data discussed above.

County Summary Data Sheet: The County Summary sheet summarizes all data for the towns, villages and cities located within the county. Documented information includes photo year, county name, an alphabetical listing of all civil jurisdictions within the county, and a summary of all land use, shoreline and

structure count data reported on Civil Jurisdiction Summary Data sheets.

LIMITATIONS AND SOURCES OF ERROR

The U.S. Army Corps of Engineers contracted for aerial photography of the Wisconsin portion of the Lake Michigan shoreline on April 21, 1978 and May 19, 1992. Both sets of photos are 1:6000 scale and panchromatic color, however, the 1978 photos are "leaves-off" while the 1992 photos are "leaves-on."

Copies of the original stereo photos (1:6000 scale) were not available for this study. Instead, enlargements (1:2400 scale) of the original photos were borrowed from Corps district offices in Green Bay and Waukesha. The enlargements provided photographic coverage only, not stereo coverage. Normally, for a project of this magnitude, photos would have been taken to meet the specific objectives of the study. The enlarged photos used for this project present limitations and introduce error beyond what would be reported with original photos flown specifically for this study. Limitations and errors associated with the photographs used are discussed below. Also presented below is discussion regarding methodological inconsistencies.

The following discussion of Limitations and Sources of Error is presented in an attempt to provide the reader a basic understanding of the issues. Any section of the discussion could apply to any of the results reported below. The Results sections of this report present findings without any comprehensive attempt to explain anomalies within, or between, the photo study years (1978 and 1992).

Photo Scale and Enlargements

All vertical aerial photographs not ratioed (enlarged or reduced to a common average scale) or rectified (common tilt/tip corrected to a horizontal reference plane) inherently are scale inaccurate. The original USACE photos (1978 and 1992) were not ratioed or rectified, therefore, their scale varies relative to topographic changes of the coastal zone, tip/tilt of the camera and changing elevation of the camera (aircraft). Enlargements of the original photos simply accentuate the inaccuracies found on the original photos.

Area and linear measurements taken off of the USACE enlarged photos reflect the inaccuracies inherent in those photos. Simple tests of shoreline distances for numerous PLSS sections within each county were conducted to establish linear accuracies of the photos. USGS topo sheets at 1:24000 scale were used to establish base shoreline distance measurements against which photo (1978 and 1992) shoreline distance measurements could be compared. No systematic errors were detected for the 1978 photos. However, only one (1) of 21 tests of the 1992 photos varied in the positive direction from USGS measurements. The remaining 20 tests varied in the negative direction and ranged from -0.8% to

-13.1%. The range of error, for 1978 was -5.3% to +9.6%, while the range of error for 1992 was -13.1% to +1.9% (see Table 1 page 17). Without a test of error for each photo used, there is no means to judge the direction or the amount of error relative to statistics associated with each photo. However, given the range of error found for the 1978 and 1992 photos, it is possible that 1,000 acres (405 ha) (actual) of coastal zone area could be reported as 1,096 acres (444 ha) in 1978 and 869 acres (352 ha) in 1992, a 227 acre (92 ha) difference.

"Leaves-On" Versus "Leaves-Off" Aerial Photography

There are distinct advantages and disadvantages of both "leaves-on" and "leaves-off" aerial photography. However, given the goals of this project, the 1978 "leaves-off" photography offers important advantages over the 1992 "leaves-on" photography. Vegetation in leaf can hide the details of built structures, including buildings and shoreline modifications. Roads can be hidden under tree crowns, as well as portions of lots landscaped and managed as residential land. Leaved canopies increase the effect of shadows. Shadows mask ground, understory and structural information leading to inaccurate interpretation. Land uses and/or structures hidden under the canopy of vegetation or masked by shadows can be underestimated in area, length or count. Land use types particularly affected (underestimated) are single family residential and wetland.

Stereo Versus Photographic Coverage

Both the 1978 and 1992 photo sets were taken to capture stereo (3-D) coverage of the Lake Michigan coastal area. This means that adjacent photos overlap approximately 60%. Stated another way, 60% of the shoreland area located on one photo also is located on an adjacent photo. The shoreland common to adjacent photos is "seen" from two different perspectives which allows stereo viewing (using a stereoscope).

The enlarged photos borrowed from USACE for this study represent photographic coverage only, or every other photo taken of shoreland. While photo (2-D) coverage at large scales can be used to interpret accurately many land use types (agricultural and most urban land), the lack of stereo viewing makes difficult the identification of wetland types and the exact location of bluff lines. Stereo viewing generally would have increased the interpretive accuracy of most land use, structural and shoreline features.

Incomplete Photo Coverage

For this study, the coastal zone is defined as a 1000' strip of land adjacent and parallel to the shoreline. Occasionally, photo coverage did not include all shoreland within 1000' of the water. As a result, total land area is underrepresented, the

exact land use types not covered are not known. In such cases, the area not captured on a particular photo was estimated by reference and comparison to coverage photos of the other flight year.

Missing Photo Coverage

Occasionally, photo coverage was missing from the USACE photo library. In such cases, as described above, coverage area missing was estimated by reference to photos of the other flight year. However, the exact land use types and shoreline features not represented on photos remain unknown.

Location of 1000' Coastal Zone Boundary

On each photo set, 1978 and 1992, a boundary line was drawn representing the 1000' coastal zone parallel to the shoreline. This line was located by scribing a landward line parallel to the line defined by the shoreline (where water meets land). The landward extent of the boundary line is a function of shoreline location, which in turn, is dependent on the water elevation of Lake Michigan. USACE (1978, 1992) reports that in April of 1978 Lake Michigan water elevation was about 578.4 feet (176.3 meters) and about 579.16 feet (176.5 meters) in May, 1992. The nine (9) inch difference in water elevation, while seemingly insignificant, could have shifted substantially landward the shoreline in extremely low slope beach or mud flat areas. The result of such a shift would be inclusion of inland areas NOT included in the 1978 coastal zone.

Lack of Beach Type in Classification Scheme

The width or extent of beach is dependent on slope of an area and water elevation. Since changes in the area of beach likely would reflect more the differences in 1978 and 1992 water levels (9 inches higher in 1992) than actual losses/gains due to erosion or development, no beach type was included in the study.

The lack of a beach type does affect measurement of area within the 1000' coastal zone. The landward extent of the coastal zone is 1000' from the shoreline. Any beach area lies between the shoreline and the base of the bluff, however area measurements of land use types were made only for those types lying between the base of the bluff and the interior boundary of the coastal zone. In most cases, beach strips represent only about five (5) acres per photo.

Positional Changes to the Shoreline: Natural vs. Urban Development

As discussed above, the landward extent of the 1000' coastal boundary is dependent on the location of the shoreline. Natural changes to shoreline position include both water elevation and

erosion/deposition of soil. Filling of coastal waters to accommodate urban development artificially changes shoreline location. In such cases, not only does the shoreline move "offshore," the interior coastal zone boundary line shifts toward the water. This "shift" in coastal boundaries skews area measurement. For example, in 1978 assume the coastal zone in an area to be all residential and that by 1992 100 acres of lake water is filled to develop commercial land. A "lakeward" shift in the location of the shoreline will occur due to the land filled for commercial use. However, this "shift" in the shoreline created by the filled commercial site also will result in a shift toward the water of the interior coastal zone boundary. The effect of the latter shift will be that 100 acres of residential land will not be included as part of the 1992 coastal zone. In such a case, the "raw' statistics misleadingly suggest that 100 acres of residential land use were eliminated to make room for 100 acres of commercial use.

RESULTS

Sheboygan County Statistics

Sheboygan County communities lying within the Lake Michigan coastal zone include the townships of Holland, Mozel, Sheboygan and Wilson, and the city of Sheboygan. The area measured within the coastal zone of Sheboygan County was 2,695 acres (1,091 ha) in 1978 and 2,816 acres (1,140 ha) in 1992. This represents a difference of 121 acres (49 ha) or 4.5%. The 1978 photo coverage of the county's coastal zone was incomplete. Missing photos accounted for 146 acres (59 ha) of coastal zone area. amount is added to existing 1978 photo coverage, the total increases to 2,814 acres (1,140 ha), just 25 acres (10 ha) more than the 1992 total. While the amount lost can be estimated, the types and amounts of land use missing can not be determined. Area discrepancies likely are the result of errors inherent in the enlarged aerial photos, as discussed on pages 12 through 15. Using USGS maps as control, tests were conducted on the linear accuracy of the Sheboygan County photos. Results of tests applied to the 1978 photos indicate some departure (-2.5% and +4.6%) from USGS measurements. Results of tests applied to the 1992 photos indicate errors of -1.2 to -3%. While the range of error appears small, it could yield a 215 acre (87 ha) difference between the 1978 and 1992 totals (Table 1).

Statistical summaries for Sheboygan County and all communities included in this study are located in the Appendix. Summary data sheets present land use types by area, structural

¹Area figures used in the Results discussion reflect totals (not rounded) reported on the original tally sheets. Figures presented on the tally sheets found in the Appendix of this report have been rounded to the nearest whole number.

Table 1. County Results of Linear Accuracy Tests

Percent Deviation From USGS Base Map Measurements

	1978 Enlarged Photos	
County	(1:2400)	(1:2400)
Brown	-0.4%	- 8.5%
BLOWII	0.03%	-5.5%
	0.034	-3.34
Door	1.3%	-1.1%
	3.9%	-3.6%
Kenosha	-2.5%	-9.0%
	3.1%	-1.6%
V	- 1.5%	-5.4%
Kewaunee	2.1%	-9.6%
	2.13	-9.0%
Manitowoc	-1.7%	-6.4%
	2.0%	-7.4%
Marinette (one test)	9.6%	-1.7%
·		
Milwaukee	-4.9%	-6.9%
	- 5.3%	1.9%
Oconto	2.9%	10.00
Oconto	2.9₹ 8.5 %	-10.8% -13.1%
	0.55	-13.14
Ozaukee	0.2%	-5.7%
	1.3%	-4.4%
	2000	
Racine	-3.0%	-5.0%
	2.2%	-0.8%
Sheboygan	-2.5%	-1.2%
	4.6%	-3.0%
Mean	0.95%	-5.18%
Range	-5.3% to 9.6%	-13.1% to 1.9%

counts by type (1992), shoreline modification types by length, and a count of shoreline structures by type. Data were collected at the PLSS section level. While the section level data sheets are not included in this report, copies are available upon written request.

Residential Land

Within the coastal zone of Sheboygan County, 2,655 residential structures were identified on 554 acres (224 ha) of land. Of the total were 1,694 residential units (single family or duplexes), 742 detached garages, 196 sheds and (8) barns. New in 1992 were 16 acres (6.5 ha) of land devoted to low rise multifamily dwellings. Since the 1992 photos are "leaves-on," these numbers likely underestimate the actual number of structures and area devoted to residential uses. In 1978, 473 acres (192 ha) of residential land were measured.

Commercial and Industrial Land

Commercial land represented 15.6 acres (6.4 ha) in 1992 and (6) acres (2.4 ha) in 1978. Twenty-three (23) commercial structures were noted within the coastal zone. Two (2) commercial types experienced growth over the 14 year period studied. The type business district increased from 4.2 acres (1.7 ha) in 1978 to 9.5 acres (3.9 ha) in 1992. Institutional land increased from 1.8 acres (.7 ha) to 6.1 acres (2.5 ha) for the same period.

No industrial land was located in 1978 compared to 66 acres (27 ha) in 1992.

Transportation Land

Fifty-five (55) structures were located on 90 acres (36 ha) of transportation land in 1992. In 1978, 85 acres (34 ha) of transportation land were reported, (5) acres fewer than in 1992. Most transportation types remained stable in area over the study period. Public boat landing, however, increased from no area in 1978 to 8.2 acres (3.3 ha) in 1992.

Agricultural and Natural Land

Overall, 82 acres (33 ha) of agricultural and natural lands were reported lost from 1978 to 1992, a trend that continues nationally. Land actively being cultivated declined by 163 acres (66 ha) or by 27.3%. Both abandoned fields and forest lands increased in area, by 51 (21 ha) and 73 acres (30 ha), respectively.

Areas of erosion along Lake Michigan's shoreline are a major concern of coastal resource planners. In 1978, 74 acres (30 ha) of land slumpage (slump zone) were detected. In 1992, this total fell to 62 acres (25 ha). Also of note is a 19 acre (7.7 ha)

decline of wetland types. The loss could be actual and attributed to both urban development and the nine (9) inch rise in Lake Michigan water level. However, a portion of the loss could be attributed to the underestimation of wetlands while using "leaves-on" photos.

Open and Other Land

Open and other land increased from 142 acres (57 ha) in 1978 to 166 acres (67 ha) in 1992. Twenty-five (25) acres (10 ha) of outdoor recreational land were added during the period while land devoted to open lot declined by one (1) acre (.4 ha).

Shoreline Modifications

Ostensibly, sea walls and revetments are used to protect shorelines from erosion. Significant increases of both types of structures were reported. In 1978, 2,120 feet (646 m) of sea wall were reported compared to 4,117 feet (1,255 m) in 1992, representing an increase of 1,997 feet (609 m) or 94%. However, more significant is the 7,829 foot (3,171 m), 27% increase in revetment development since 1978. Shoreline revetment was measured at 28,710 feet (8,753 m) in 1978 and 36,539 feet (11,140 m) in 1992.

Results by Community

Town of Holland

Land within Holland's coastal zone was measured at 710 acres (287 ha) in 1978 and 680 acres (276 ha) in 1992. The difference of 30 acres (12 ha) represents 4.2%. The source of the difference could be photo scale anomalies as discussed above.

In 1992, 416 residential structures were located on 93 acres (38 ha) of land. Most of these structures (280) were single family or duplex. In 1978, 88 acres (36 ha) of residential area are reported.

Commercial area remained stable over the study period, with less than 1/2 of an acre reported for each year. No industrial or transportation types were located in 1978 or 1992.

Agricultural and natural areas decreased from 621 acres (252 ha) in 1978 to 586 acres (238 ha) in 1992. Active agricultural land declined by 33 acres (13 ha) or 35% while forest land increased by 25 acres (10 ha) or 6.8%. The type abandoned field lost 23 acres (9.3 ha) during the period. Wetlands remained stable.

From 1978-1992, some shoreline modification has occurred within the town. Sea wall construction increased by 258 feet (79 m) or 41%, from 627 feet (191 m) to 885 feet (270 m). Revetment, however, declined from 7,193 feet (2,193 m) to 5,510 feet (1,680 m). The loss, while unexplained, could be the result of "leaves-on" photos which make detection under tree canopy more difficult.

Town of Mosel

Coastal zone area within the township was measured at 706 acres (286 ha) in 1978 and 674 acres (273 ha) in 1992, a difference of 32 acres (13 ha). The town of Mosel was one of those tested for linear accuracy of photo coverage. Using USGS maps at 1:24000, measurements taken from the 1978 photos were +4.6% of the USGS basis. The 1992 photos deviated by -3% from the USGS basis.

In 1992, a total of 101 residential structures were identified on 45 acres (18 ha) (40 acres [16 ha] in 1978) of residential land. Of these, 33 were of the single family/duplex type.

In neither year was there recorded any commercial, industrial or transportation lands.

For both study years, well over 90% of all coastal zone land within Mosel fell into the category agricultural and natural. This category decreased from 666 acres (270 ha) to 630 acres (255 ha) for the period studied. Other changes include a 50 acre (20 ha) increase in abandoned field, an 82 acre (33 ha) decrease in active agricultural fields, and a 45 acre (18 ha) increase in forest land. Significant reductions in slump zone and wetlands were noted as well. Slump zone declined by 11 acres (4.5 ha) or by just under 20% while wetlands declined by 38 acres (16 ha) or by 68%.

No open or other land types were registered for 1978 or 1992.

Results indicate a loss of 1,047 feet (319 m) of sea wall. The loss likely represents masking by leaves and shadows rather than actual losses of shoreline structures. No other coastline structures were identified.

City of Sheboygan

The analysis of land use change within the coastal zone of the city of Sheboygan is made difficult by two factors: missing photo coverage for 1978, and annexation of land after 1978. The coastal zone in 1992 consisted of 675 acres (273 ha), 78 acres (32 ha) of which were annexed from the town of Sheboygan. In 1978, 405 acres (164 ha) of coastal zone area were estimated using available photos. Missing 1978 photos covered an estimated 146 acres (59 ha) of area. Therefore, the total 1978 coastal zone area is estimated to be 551 acres (223 ha). While it was possible to estimate the area not covered by 1978 photos, it was not possible to determine what land uses (or their areas) were missed. This fact should be remembered when considering the statistics found below and in the Appendix.

Residential land encompassed 354 acres (143 ha) in 1992, 236 acres (95 ha) were located on available 1978 photos. Over 1,900 structures, of which 1,212 were single family/duplex, were located within the 1992 coastal zone. Other structures included 637 detached garages and 39 sheds.

Commercial uses covered 15 acres (6.3 ha) in 1992. Twenty (20) structures were located on 9.3 acres (3.8 ha) of neighborhood business district area while two (2) structures were reported on 6.1 acres (2.5 ha) of institutional land. Also in 1992, 38 industrial structures were located on 66 acres (27 ha) of land.

Transportation types covered 90 acres (37 ha) of area in 1992. Of these, utilities covered the largest area (61 acres [25 ha]) and held the most structures (36). Sewage treatment facilities remained stable in area from 1978 to 1992 at about 15 acres (6.1 ha). While no public boat landing was located in 1978, 8.2 acres (3.3 ha) were developed by 1992. The problem of missing photos and annexation skew the statistics regarding agricultural and natural lands against observed trends. Local and national trends suggest that such lands generally are declining, especially adjacent to urban areas. In 1992, 86 acres (35 ha) of area were identified within the agricultural and natural use category. Of these were 31 acres (12.6 ha) of abandoned field, 27 acres (11 ha) of active agriculture and 10 acres (4.1 ha) of wetland.

In the open/other land use category, 63 acres (25 ha) were identified as outdoor recreation. Ten (10) structures were counted on these areas.

In 1992, 3,164 feet (965 m) of sea wall and 22,466 feet (6,850 m) of revetment were recorded.

Town of Sheboygan

The coastal zone for the town of Sheboygan was determined to be 219 acres (89 ha) in 1978 and 150 acres (60 ha) in 1992. However, annexation to the city of Sheboygan resulted in a loss of 78 acres (32 ha) of land. This area represents a 35% loss relative to the 1978 total. Given the annexation, a comparison of 1978-1992 land use within the coastal zone is problematic.

The amount of residential land located within the coastal zone was 19 acres (7.8 ha) in 1992. Within the residential area were counted 19 structures, 16 of which were identified to be single family/duplex.

No commercial, industrial, transportation or extractive land uses were identified for either 1978 or 1992.

In 1992, agricultural an natural lands covered an area of 130 acres (53 ha). Most area fell within the use types abandoned field - 38 acres (15 ha), active agricultural - 31 acres (12.6 ha), forest - 31 acres (12.5 ha) and wetland - 21 acres (8.5 ha).

No sea walls were identified in either study year. In 1992, 972 feet (297 m) of revetment were measured along the town's shoreline.

Town of Wilson

The coastal zone of the town of Wilson was determined to be 656 acres (266 ha) in 1978 and 637 acres (258 ha) in 1992. The

19 acre (7.7 ha) difference is 2.9% of the 1978 total. The town of Wilson was one of the sites tested to determine linear accuracy of the enlarged photos. The 1978 photos of Wilson were determined to deviate -2.5% from USGS 1:24000 maps. The 1992 photos deviated by +1.2% from the USGS basis.

Total residential land located within the coastal zone remained stable from 1978 to 1992 at about 60 acres (24 ha). In 1992, 216 structures were located within the residential area. Included in the total were 153 single family/duplex units, 39 detached garages and 24 sheds.

Within the coastal zone, no commercial or industrial lands were identified for either study year.

In 1978, 11.3 acres (4.6 ha) of transportation area were identified, 11.1 acres (4.5 ha) of which were identified as utility. In 1972, however, no transportation lands were logged within the coastal zone.

The category agricultural and natural remained stable (about 475 acres, 193 ha) over the 14 year study period. Most land use types within this category remained stable as well, with modest change reported for active agriculture (-12.3 acres, 5 ha), slump zone (+4.3 acres, 1.7 ha) and wetlands (-14.1 acres, 5.7 ha).

Both study years recorded just over 100 acres (40 ha) of open/other land types, 98% of which fell into the type class outdoor recreation.

Changes to shoreline were substantial from 1978 to 1992. Sea walls declined from 865 feet (216 m) in 1978 to 68 feet (21 m) in 1992. However, revetments increased by 3,302 feet (1,007 m) from a total of 3,629 feet (1,107 m) in 1978 to 6,931 feet (2,113 m) in 1992. This represents an increase of 91%.

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APPENDIX

Lake Michigan Coastal Development Inventory Project: 1978 - 1992

County Summary Data Sheet

Year: 1978

County: Sheboygan Coastal Civil Jurisdiction included in summary (in alphabetical

order).

Town of Holland Town of Mosel City of Sheboygan Town of Sheboygan - Town of Wilson

LAND USE CATEGORIES

Supplied relating control of			A 1	rea
arman in in	· · · · · · <u>#</u>	of structur	es Acres	Hectare
11 Residentia	<u>1</u>			
		: . +		
111 Res. un	its			
garages	-			
sheds	<u> </u>			
- 112 Res. un	its			
- garages	-			
sheds				
113 Res. un	its	1436	473	192
garages		644		
- sheds		246		
barns		11		
115 Res. un	its			
garages				
sheds				
t T ref	Subtotal	2337	473	192
12 Commercial	· · · · · · · · · · · · · · · · · · ·	•		
	Business Dist			
	g Center/Mall			
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	Subcocal	12	•	2
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13 Industrial	a same caraca			
12 Illanscriar				

Lake Michigan Coastal Development Inventory Project: 1978 - 1992

County Summary Data Sheet

Year: 1992

County: Sheboygan

Coastal Civil Jurisdiction included in summary (in alphabetical

order).

Town of Holland Town of Mosel City of Sheboygan Town of Sheboygan Town of Wilson

LAND USE CATEGORIES

			Ar	rea
	# of s	tructures	<u>Acres</u>	<u> Hectares</u>
11 Regidential		/		
11 Residential				
111 Res. units				
garages				
sheds				
112 Res. units		14	16	7
garages sheds		1		
113 Res. units		1694	554	224
garages	· · · · · · · · · · · · · · · · · · ·	742		
sheds	•	196		
barns		8		
115 Res. units			W	
garages		· · · · · · · · · · · · · · · · · · ·		
sheds				
	Subtotal	2655 .	570	231
12 Commercial				
IL COMMICTOTAL				
121 Central Bus	siness Dist			
122 Shopping Co	enter/Mall			
124 Neighborho			10	4
126 Institution		2	66	3
	Subtotal	23	16	6
13 Industrial				
138 Industrial	Park	38	66	27

Lake Michigan Coastal Development Inventory Project: 1978 - 1992

Civil Jurisdiction Summary Data Sheet

Year: 1978

13 Industrial

description): T13N R23E SE	C 4 C 8			
SE	C 9			
	C 17 C 19			
	C 20			
	C 30			
SE	C 31			
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			Ar	02
		# of structures		<u> Hectare</u>
				•
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sheds				
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. garages				
garages sheds				
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garages sheds 113 Res. units garages sheds		275 56 64	88	
garages sheds 113 Res. units garages sheds barns		275 56 64	88	36
garages sheds 113 Res. units garages sheds barns 115 Res. units	•	275 56 64	88	36
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garages sheds 113 Res. units garages sheds barns 115 Res. units	•	275 56 64	88	36
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garages sheds 113 Res. units garages sheds barns 115 Res. units garages sheds		275 56 64 2	88	36
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garages sheds 113 Res. units garages sheds barns 115 Res. units garages sheds 12 Commercial 121 Central Bus 122 Shopping Ce	Subtotal iness Dist nter/Mall _ d Business	275 56 64 2 397	88	36

3 Industrial
138 Industrial Park ______

Area

		# of structur	es <u>Acres</u>	<u>Hectare</u>
14 Transportation	1			
141 Air Transpo	ortation			
142 Rail Transp	ortation			
143 Water Trans	sportation			
143.1 Private N	Marina		· <u></u>	
143.1 Private M 143.2 Public Bo	nat Landing			
144 Highways				
144 Highways 145 Communicati	ons			
146 Utilities				
146 Utilities 147 Sewage Trea	tment Plant			
148 Landfill				
4-10 Bulluz 2 4 4	Subtotal	,,		
17 Extractive	Dabedear			
171 Open Pit				
171 Open Pit 172 Underground				
173 Well				
173 Well 179 Other Extra	ctive			
	Subtot	al		
18 Agricultural a	nd Natural	4 - 14 - 3		
181 AF Abandone	d Field		60	23
181 AF Abandone 182 AG Agricult	ure Active	<u> </u>	94	38
183 F Forest				149
184 H Heath			10	143
184 H Heath 185 OW Open Wat	er	***************************************		
TRE DI DOOF TOO	la o			
186 RL Rock Led	ne			
188 WT Wetland	,ne		92	37
187 SL Slump Zo	Subtotal	· 9	621	252
, sandrick , a - du	Subcocal	<i>6</i>	021	252
19 Open Land, Oth	<u>ier</u>			
191 Outdoor-Pub	olic Assembly			-
192 Urban Open	Lots			
193 Outdoor Rec	reation			
194 Cemeteries				•
	Subtotal			
,			Total Acres	71
Nagy -			Total Hectare	s 28
Shoreline Modific	ations		Lin	ear
			Feet	Mete
Mr. N.			627	19
195 Sea Walls			7193	219
196 Revetments				
			# of Groins	

Civil Jurisdiction Summary Data Sheet

County: Sheboygan

Township, Village or City name: Town of Holland PLSS section data sheets <u>included in summary</u> (give full

description):

T13N R23E Sec. 4 Sec. 8 Sec. 9 Sec. 17 Sec. 19 20 Sec. Sec. 30 Sec. 31

LAND USE CATEGORIES

3---

			Ar	'ea
	i	f of structures	Acres	<u> Hectares</u>
	_			
11 Residential				
111 Res. units				
garages				
sheds				
112 Res. units				
garages				
sheds				
113 Res. units		280	93	38
garages		55		
sheds		81		
barns	***************************************			
115 Res. units				
garages				
sheds				
	Subtotal	416	93	38
12 Commercial 121 Central Bus	iness Dist _			
122 Shopping Ce	nter/Mall			
124 Neighborhoo	d Business D:	ist <u> </u>	<1	<1
126 Institution				
	Subtotal	1	<1	<1
13 Industrial	Dowle	_		
138 Industrial	Park	-		

Area Acres Hectares

of structures

	# of structures	Acres I	<u>lectares</u>
14 Transportation			
ala Sin Maranana akakian			
141 Air Transportation			
142 Rail Transportation			
143 water Transportation _			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities 147 Sewage Treatment Plant			
148 Landfill			
Subtotal			
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subto	tal		
bubee	cai		
18 Agricultural and Natural			
181 AF Abandoned Field		33	14
181 AF Abandoned Field 182 AG Agriculture Active	31	61	
183 F Forest		392	
184 H Heath			
184 H Heath 185 OW Open Water		Ę.	2
186 RL Rock Ledge		<u> </u>	
187 SL Slump Zone			
188 WT Wetland		91	3.0
Subtotal	31	586	238
Subcocai	31	380	230
19 Open Land, Other			
191 Outdoor-Public Assembl	37		
192 Urban Open Lots	<i>Y</i>		
192 Orban Open Locs	2	1	
193 Outdoor Recreation	22	<u>+ ,</u> _	<u><1</u>
194 CemeteriesSubtotal	2	4	
Subtotal	2	1	<1
	T	otal Acres	680
	T	Cotal Hectares	276
Shoreline Modifications		Linea	ar
		<u>Feet</u>	Meters
195 Sea Walls	,	885	270
196 Revetments		5510	1680
197 Groins		# of Groins	
198 Dock Non-Flow-Through		# of Docks	
	· · · · · · · · · · · · · · · · · · ·		

Civil Jurisdiction Summary Data Sheet

Year: 1978 County: Sheboygan Township, Village or City name: Town of Mosel PLSS section data sheets included in summary (give full description): T16N R23E SEC 3 SEC 10 SEC 15 SEC 22 SEC 27 SEC 34 LAND USE CATEGORIES Area # of structures Acres Hectares 11 Residential 111 Res. units garages sheds 112 Res. units garages sheds 28 113 Res. units 40 garages 4 sheds 31 barns 3 115 Res. units garages sheds Subtotal 66 40 12 Commercial 121 Central Business Dist _ 122 Shopping Center/Mall ___ 124 Neighborhood Business Dist _ 126 Institutional Subtotal

13 Industrial

138 Industrial Park ____

Area

of structures Acres Hectares

		# or structu	res Acres	nectates
14 Tra	nsportation			
1.41	Air Transportation			
142	Rail Transportation			
143	Water Transportation _			
1.43.	1 Private Marina	····		
1.43.	1 Private Marina 2 Public Boat Landing			
144	Highways			
145	Highways Communications			· · · · · · · · · · · · · · · · · · ·
1.47	Sewage Treatment Plant			
1.48	Landfill Subtotal			
<u> 17 Ext</u>	<u>cractive</u>			
171	Open Pit	·		
172	Underground			
173	Well	. • •		
179	Underground			
	Supto	tal		
	The state of the s	en de de la company de la comp		
18 Aqr	ricultural and Natural			
101	am aha. mi .aa			
181	AF Abandoned Field AG Agriculture Active		77	31
182	AG Agriculture Active	44	417	169
183	F Forest	·	59	24
	H Heath		-	
100	OW Open Water			<1
180	RL Rock Ledge		E .	. 22
100	SL Slump Zone	 	<u>56</u> 56	23
	WT Wetland Subtotal			270
	Subtotal	44 ,	666	270
 19 Ope	n Land, Other	•		
			•	
191	Outdoor-Public Assembl	· V		
	Urban Open Lots	4		
				····································
	Cemeteries			
	Subtotal			
			Motol 1	706
		•	Total Acres Total Hectares	706 - 206
		•	Total nectares	286
Shorel	ine Modifications		Line	ear
			Feet	<u>Meters</u>
195	Sea Walls			
196	Revetments		1706	520
197	Groins		# of Groins	
198	Dock Non-Flow-Through		# of Docks	

Civil Jurisdiction Summary Data Sheet

Year: 1992 County: Sheboygan Township, Village or City name: Town of Mosel PLSS section data sheets included in summary (give full description): T16N R23E 3 Sec. Sec. 10 Sec. 15 Sec. 22 Sec. 27 Sec. 34 LAND USE CATEGORIES Area # of structures Acres Hectares 11 Residential 111 Res. units garages sheds 112 Res. units garages sheds 33 10 45_____18 113 Res. units garages sheds ____50 8 barns 115 Res. units garages sheds Subtotal 101 45 12 Commercial 124 Neighborhood Business Dist _____ 126 Institutional Subtotal

138 Industrial Park _____

13 Industrial

Area # of structures Acres Hectares

	# of structure	s <u>Acres</u>	<u> Hectares</u>
14 Transportation			
141 Air Transportation			
142 Rall Transportation _			
143 Water Transportation			
143.1 Private Marina			
143.1 Private Marina	g		
144 Highways			
144 Highways 145 Communications			
146 Utilities			
146 Utilities 147 Sewage Treatment Plan	nt		-
148 Landfill			
Subtotal			
17 Extractive			
171 Open Pit			
172 Underground			
179 Other Extractive			
Subt			
Subt	LUCAI		
18 Agricultural and Natural	<u>.</u>		
181 AF Abandoned Field		127	52
182 AG Agriculture Active	3	335	136
183 F Forest		104	42
185 OW Open Water		2	<1
186 RL Rock Ledge			
186 RL Rock Ledge		45	18
			7
Subtotal		630	255
Subcocar		630	255
19 Open Land, Other			
101 Outdoom-Dublic Accept	~1·r		
191 Outdoor-Public Assemb			
192 Urban Open Lots			
193 Outdoor Recreation _			
194 Cemeteries	· · · · · · · · · · · · · · · · · · ·		
Subtotal			
		Total Acres	674
		Total Acres Total Hectares	
		IUCAI NECLATES	273
Shoreline Modifications		Line	ar
DHOLETTHE HOUTLICACIONS		Feet	
195 Sea Walls		reec	HECELS
196 Revetments		659	201
197 Groins	• • • • • • • • • • • • • • • • • • • •	# of Groins	
198 Dock Non-Flow-Through	1	# of Docks	

Civil Jurisdiction Summary Data Sheet

Year: 1978

County: Sheboygan
Township, Village or City name: City of Sheboygan
PLSS section data sheets included in summary (give full

description):

man a galan par

T15N R23E SEC 2 SEC 11 SEC 14 SEC 14 SEC 23 SEC 26 SEC 35

LAND USE CATEGORIES

			Ar	ea
		f of structures	<u>Acres</u>	<u> Hectares</u>
11 Residential				.
111 Res. units		ř		
garages				
sheds				
112 Res. units	-	•	•	
garages			·	
"113 Res. units		925	236	95
garages		531	230	
sheds		107		
barns		1		
115 Res. units				
garages				
sheds				
	Subtotal	1564	236	95
12 Commercial		·		
121 Central Bus				
122 Shopping Ce	nter/Mall _			
124 Neighborhoo	d Business	Dist <u>8</u>	4	2
126 Institution		2	2	1
	Subtotal	10	6	2
13 Industrial	· · · · · · · · · · · · · · · · · · ·			
138 Industrial	Park	. •••		

		Area	2
	<pre># of structures</pre>	Acres	<u>Hectare</u>
14 Transportation			
141 Air Transportation 142 Rail Transportation			
142 Rail Transportation _		2	1
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways 145 Communications		7	3
145 Communications	<u> </u>	<1	<1
146 Utilities	17	50	20
147 Sewage Treatment Plant	15	14	6
148 Landfill			
Subtotal	33	74	30
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
173 Well 179 Other Extractive			*
Subto	ntal		
	Jeur		
18 Agricultural and Natural			
181 AF Abandoned Field		14	6
182 AG Agriculture Active		1	6 <1
182 AG Agriculture Active 183 F Forest		<u>1</u> 23	
182 AG Agriculture Active 183 F Forest 184 H Heath		23 2	<1 9 1
182 AG Agriculture Active 183 F Forest 184 H Heath		23 2	<1 9
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge		23 2	<1 9 1 <1 <1
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge		23 2	<1 9 1 <1 <1
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland		1 23 2 <1 1	<1 9 1 <1 <1
182 AG Agriculture Active 183 F Forest 184 H Heath		1 23 2 <1 1	<1 9 1 <1 <1 4
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland		1 23 2 <1 1 10 <1	<1 9 1 <1 <1 <1 4
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal		1 23 2 <1 1 10 <1	<1 9 1 <1 <1 <1 4
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble	Ly	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assembles Urban Open Lots	Ly	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation	Ly	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries	Ly6	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation	Ly	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries	-Y6_	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries	Ly	1 23 2 <1 1 10 <1 51	<1 9 1 <1 <1 4 <1 20 <1 16 405
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries Subtotal	Ly	1 23 2 <1 1 10 <1 51 51	<1 9 1 <1 <1 4 <1 20 <1 16 405 164
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries Subtotal Shoreline Modifications	Ly	1 23 2 <1 1 10 <1 51 51 <1 39 39 Al Acres Al Hectares Line Feet	<1 9 1 <1 <1 4 <1 20 <1 16 405 164 ear Meter
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries Subtotal	Ly	1 23 2 <1 1 10 <1 51 51 <1 39 39 Al Acres Al Hectares Line Feet 636	<1 9 1 <1 <1 4 <1 20 <1 16 405 164 ear Meter 194
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assemble 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries Subtotal Shoreline Modifications	6 6 Tota	1 23 2 <1 1 10 <1 51 51 51 51 Line Feet 636 14548	<1 9 1 <1 <1 4 <1 20 <1 16 405 164
182 AG Agriculture Active 183 F Forest 184 H Heath 185 OW Open Water 186 RL Rock Ledge 187 SL Slump Zone 188 WT Wetland Subtotal 19 Open Land, Other 191 Outdoor-Public Assembled Substant 192 Urban Open Lots 193 Outdoor Recreation 194 Cemeteries Subtotal Shoreline Modifications 195 Sea Walls	6 Tota	1 23 2 <1 1 10 <1 51 51 <1 39 39 Al Acres Al Hectares Line Feet 636	<1 9 1 <1 <1 4 <1 20 <1 16 405 164 ear Meter 194

Civil Jurisdiction Summary Data Sheet

Year: 1992 County: Sheboyo Township, Villac PLSS section dat description):	ge or City n	ame: City of Shek cluded in summary	ooygan (give full	
T14N R23E	Sec. 2			
T15N R23E	Sec. 2 Sec. 11 Sec. 14 Sec. 23 Sec. 26 Sec. 35			
	LAND	USE CATEGORIES		
		# of structures		ea <u>Hectares</u>
11 Residential				
111 Res. units garages sheds	.			
112 Res. units	s	14	16	7
garages sheds		1		
sneas 113 Res. units		1212	338	137
garages		637		
sheds		39		
barns 115 Res. units garages sheds	s			
Sileus	Subtotal	1903	354	143
12 Commercial				
121 Central Bu	usiness Dist			
122 Shopping (Center/Mall	Di-t 00		
124 Neighborho 126 Institutio	ood Business	Dist 20 2	<u>9</u> 6	<u>4</u> 3
120 Illacituti	Subtota		15	<u>3</u>
		_	_	-

138 Industrial Park ______ 38 66

13 Industrial

of structures Area Acres Hectares
141 Air Transportation
141 Air Transportation 2 1 142 Rail Transportation 2 1 143 Water Transportation 3 1 143.1 Private Marina 3 3 144.2 Public Boat Landing 8 8 3 144.4 Highways 4 2 145.5 Communications 1 <1
143 Water Transportation 143.1 Private Marina
143 Water Transportation 143.1 Private Marina
143 Water Transportation 143.1 Private Marina
143.1 Private Marina 143.2 Public Boat Landing 8 8 3 144 Highways 4 2 145 Communications 1 <1 <1 <1 146 Utilities 36 61 25 147 Sewage Treatment Plant 10 16 6 148 Landfill Subtotal 55 90 37 17 Extractive 171 Open Pit 172 Underground 173 Well 179 Other Extractive Subtotal 181 AF Abandoned Field 31 13 182 AG Agriculture Active 183 F Forest 27 11 184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 1 <1
144 Highways 4 2 145 Communications 1 <1
144 Highways 4 2 145 Communications 1 <1
145 Communications 1 <1
146 Utilities 36 61 25 147 Sewage Treatment Plant 10 16 6 148 Landfill Subtotal 55 90 37 17 Extractive 171 Open Pit 172 Underground 173 Well 179 Other Extractive Subtotal 18 Agricultural and Natural 181 AF Abandoned Field 31 13 182 AG Agriculture Active 183 F Forest 27 11 184 H Heath 184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
147 Sewage Treatment Plant 10 16 6 148 Landfill Subtotal 55 90 37 17 Extractive 171 Open Pit 172 Underground
148 Landfill Subtotal 55 90 37
Subtotal 55 90 37
171 Open Pit 172 Underground 173 Well 179 Other Extractive Subtotal 18 Agricultural and Natural 181 AF Abandoned Field 31 13 182 AG Agriculture Active 183 F Forest 27 11 184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
172 Underground 173 Well 179 Other Extractive Subtotal 18 Agricultural and Natural 181 AF Abandoned Field 31 13 182 AG Agriculture Active 183 F Forest 27 11 184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
172 Underground 173 Well 179 Other Extractive Subtotal 18 Agricultural and Natural 181 AF Abandoned Field 31 13 182 AG Agriculture Active 183 F Forest 27 11 184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
173 Well 179 Other Extractive Subtotal 18 Agricultural and Natural 181 AF Abandoned Field 31 13 182 AG Agriculture Active 183 F Forest 27 11 184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
179 Other Extractive Subtotal
Subtotal 18 Agricultural and Natural 181 AF Abandoned Field
181 AF Abandoned Field 31 13 182 AG Agriculture Active 27 11 183 F Forest 27 11 184 H Heath 9 4 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
182 AG Agriculture Active
182 AG Agriculture Active
183 F Forest 27 11 184 H Heath 9 4 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
184 H Heath 185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
185 OW Open Water 9 4 186 RL Rock Ledge 1 <1
186 RL Rock Ledge1 <1
186 RL Rock Ledge
187 SL Slump Zone 8 3
188 WT Wetland 10 4
Subtotal 86 35
19 Open Land, Other
191 Outdoor-Public Assembly
191 Outdoor-Public Assembly
193 Outdoor Recreation 10 63 25
194 Cemeteries
Subtotal 10 63 25
Mohol Davis Cit
Total Acres 675 Total Hectares 273
<u>Shoreline Modifications</u> Linear
<u>Feet Meters</u>
195 Sea Walls
196 Revetments
107 Amelia - 1
197 Groins # of Groins 198 Dock Non-Flow-Through # of Docks

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Civil Jurisdiction Summary Data Sheet

Year: 1978

County: Sheboygan Township, Village or City name: Town of Sheboygan PLSS section data sheets included in summary (give full

description):

T14N R23E SEC 2 SEC 3 SEC 11

		rassing of a constraint	a same	Ar	ea
			# of structures	Acres	Hectares
11 Re:	<u>sidential</u>			%	t. But
- 111	Res. units	"			
	garages	-			
	sheds				
	Res. units		·		· · · · · · · · · · · · · · · · · · ·
	garages sheds			•	
113	Res. units		23	47	19
	garages	•	1		
	sheds		11		
115	barns Res. units		1		
115	garages				
	sheds				
		Subtotal	36	47	19
12 Co	mmercial	· - ·	. *		
121	Central Bus	iness Dist			
122	Shopping Ce	nter/Mall _			
			Dist		
126	Institution	Subtotal			

1633 # of Groins

of Docks

of structures Acres Hectares 14 Transportation 141 Air Transportation __ 142 Rail Transportation ______ 143 Water Transportation ______ 143.1 Private Marina ____ 143.2 Public Boat Landing _ 144 Highways 145 Communications 146 Utilities ___ 147 Sewage Treatment Plant _ 148 Landfill Subtotal 17 Extractive 171 Open Pit 172 Underground 173 Well 179 Other Extractive Subtotal 18 Agricultural and Natural 181 AF Abandoned Field 182 AG Agriculture Active 67 183 F Forest ____ 29 184 H Heath 185 OW Open Water ____ 186 RL Rock Ledge
187 SL Slump Zone
188 WT Wetland 28 Subtotal 19 Open Land, Other 191 Outdoor-Public Assembly _____ 192 Urban Open Lots __ 193 Outdoor Recreation _ 194 Cemeteries Subtotal Total Acres 219 Total Hectares Shoreline Modifications Linear Feet Meters 195 Sea Walls

196 Revetments

198 Dock Non-Flow-Through

197 Groins

Civil Jurisdiction Summary Data Sheet

Year: 1992

County: Sheboygan Township, Village or City name: Town of Sheboygan PLSS section data sheets included in summary (give full

description):

T15N R23E Sec. 2 Sec. 3

Sec. 11

LAND USE CATEGORIES

			Ar	·ea
		# of structures	Acres	<u> Hectares</u>
11 Residential				
111 Res. units garages sheds				
112 Res. units garages sheds				
113 Res. units garages sheds barns		16 1 2	19	8
115 Res. units garages sheds				
	Subtotal	19	19	8
12 Commercial				
121 Central Bus 122 Shopping Ce 124 Neighborhoo 126 Institution	nter/Mall _ d Business			
13 Industrial				
120 Industrial	Dark			

Civil Jurisdiction Summary Data Sheet

Year: 1978

County: Sheboygan Township, Village or City name: Town of Wilson PLSS section data sheets included in summary (give full description): T14N R23E SEC 2 SEC 11 SEC 14 SEC 22 SEC 23 SEC 27 SEC 33 SEC 34 والمرابع والمرابع والمنطور والمرابع والمرابع والمرابع والمرابع والمرابع والمرابع والمعارض والمرابع LAND USE CATEGORIES and the second of the second o # of structures Acres Hectares 11 Residential ---- 111 Res. units _____ garages sheds 112 Res. units garages _____ sheds ____ --- 113 Res. units ______ 185 62 garages sheds 52 barns 115 Res. units ··-- garages - sheds 62 Subtotal 274 12 Commercial 121 Central Business Dist _____ 122 Shopping Center/Mall ____ 124 Neighborhood Business Dist ____ 126 Institutional _ Subtotal and the form of the control of the c

13 Industrial

138 Industrial Park _____

3629

of Groins

of Docks

1107

14 Transportation

144 Highways

146 Utilities

148 Landfill

171 Open Pit 172 Underground __

186 RL Rock Ledge 187 SL Slump Zone _ 188 WT Wetland e l

194 Cemeteries

195 Sea Walls

197 Groins

196 Revetments

198 Dock Non-Flow-Through

17 Extractive

173 Well

Civil Jurisdiction Summary Data Sheet

Year: 1992 County: Sheboyga Township, Village PLSS section data description):	or City na	nme: Town of Wilso cluded in summary (n give full	
	Sec. 2 Sec. 11 Sec. 14 Sec. 22 Sec. 23 Sec. 27 Sec. 33 Sec. 34			
	LAND	USE CATEGORIES		
		# of structures	Are Acres	ea <u>Hectares</u>
11 Residential				
111 Res. units garages sheds 112 Res. units garages				
sheds 113 Res. units garages sheds barns		153 39 24	59	24
115 Res. units garages sheds	Subtotal	216	59	24
12 Commercial				2 -
121 Central Bus	nter/Mall _ d Business	Dist		

138 Industrial Park _____

		Area		
	# of structure	es <u>Acres</u>	<u>Hectares</u>	
14 Transportation				
141 Riv Musuamentotion				
141 Air Transportation 142 Rail Transportation				
142 Water Transportation _				
143 Water Transportation _				
143.1 Private Marina				
143.2 Public Boat Landing				
144 Highways 145 Communications				
146 Utilities				
147 Sewage Treatment Plant	.			
147 Sewage Treatment Flant 148 Landfill				
Subtotal	·			
Subcotai				
17 Extractive				
171 Open Pit				
171 Open Pit 172 Underground				
173 Well				
179 Other Extractive				
Subto	otal			
18 Agricultural and Natural	-			
181 AF Abandoned Field		16	6	
181 AF Abandoned Field 182 AG Agriculture Active	***	6	3	
183 F Forest		342	138	
	1		32	
185 OW Open Water		1	<1	
186 RL Rock Ledge				
18/ SL Slump Zone		4	11	
188 WT Wetland		2.0	11	
Subtotal		475	193	
19 Open Land, Other				
191 Outdoor-Public Assembl	Ly			
192 Urban Open Lots		1	1	
193 Outdoor Recreation	8	102	41	
194 Cemeteries				
Subtotal	8	103	42	
		Total Acres	637	
		Total Hectares		
Shoreline Modifications	•	Line	ar	
		<u>Feet</u>	Meter	
195 Sea Walls		68	2.1	
196 Revetments		6931	211.3	
197 Groins		# of Groins		
198 Dock Non-Flow-Through		# of Docks		

3 6668 14109 6810